Transient Stability Analysis with PowerWorld Simulator

T5: Transient Contingencies

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Transient Stability Analysis: PowerWorld's Design Goal

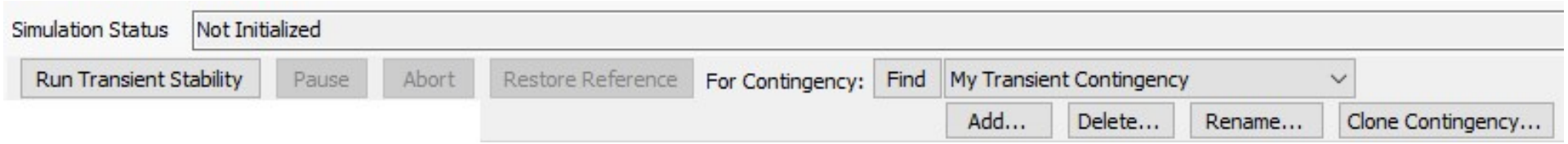
- Traditional transient stability
  - Create one set of events which define your transient stability simulation
  - Similar to having a tool to solve one power flow solution
- PowerWorld's Design Goal
  - Mimic the processing of Simulator's Contingency Analysis
  - Define multiple contingencies and process them all
  - This section will concentrate on defining a single transient contingency
- This leads to creating a new object in Simulator called a *Transient Contingency*
  - Similar to Contingency records except a different set of actions are available
  - Also timing inputs are important

Transient Contingencies

- Goal - to simulate a particular contingency and see if it causes any problems for the system
- A transient contingency will consist of one or more events
- One contingency might be the outage of a generator to gauge the response of the governors of the remaining generators
- Another contingency might simulate a bus fault, which has events to both initiate and clear the fault

Defining a Transient Contingency

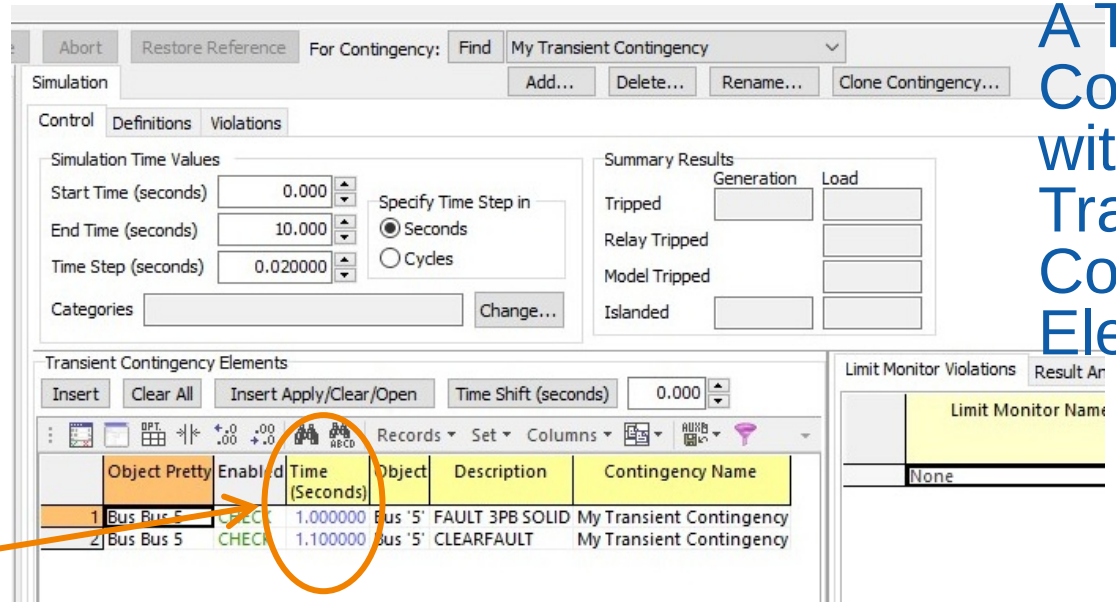
- A new contingency will automatically be given an unused name starting with “My Transient Contingency”
- Several buttons for processing transient contingencies are normally available at the top of the dialog, regardless of the page
- More than one contingency may be specified



- Use Add, Delete, and Rename buttons to manage the transient contingencies
- Use the drop-down menu to choose the presently active contingency from a list of available contingencies

Transient Contingency

- Specify Start and End Time
- Specify Time Step (seconds or cycles)
  - Recommend either 0.5 cycles or 0.25 cycles
- Transient Contingencies have one or more Transient Contingency Elements to specify the events that occur during the simulation
  - Fault Bus
  - Open Line
  - Etc…



A Transient Contingency with two Transient Contingency Elements

Events occur at specified times

Transient Contingency Elements

- Insert Elements Button
  - Opens the Transient Stability Contingency Element Dialog
- Clear All Elements
  - Deletes all currently defined events
- Insert Apply and Clear Fault
  - Quickly apply/clear a fault by specifying both its fault time and its clearing time in one dialog
- Element Table
  - A case information display which lists all transient stability elements currently defined for the Transient Contingency
  - Clicking on an event and choosing “Show Dialog” option will open the Transient Stability Contingency Element Dialog

Transient Contingency Element Actions Types

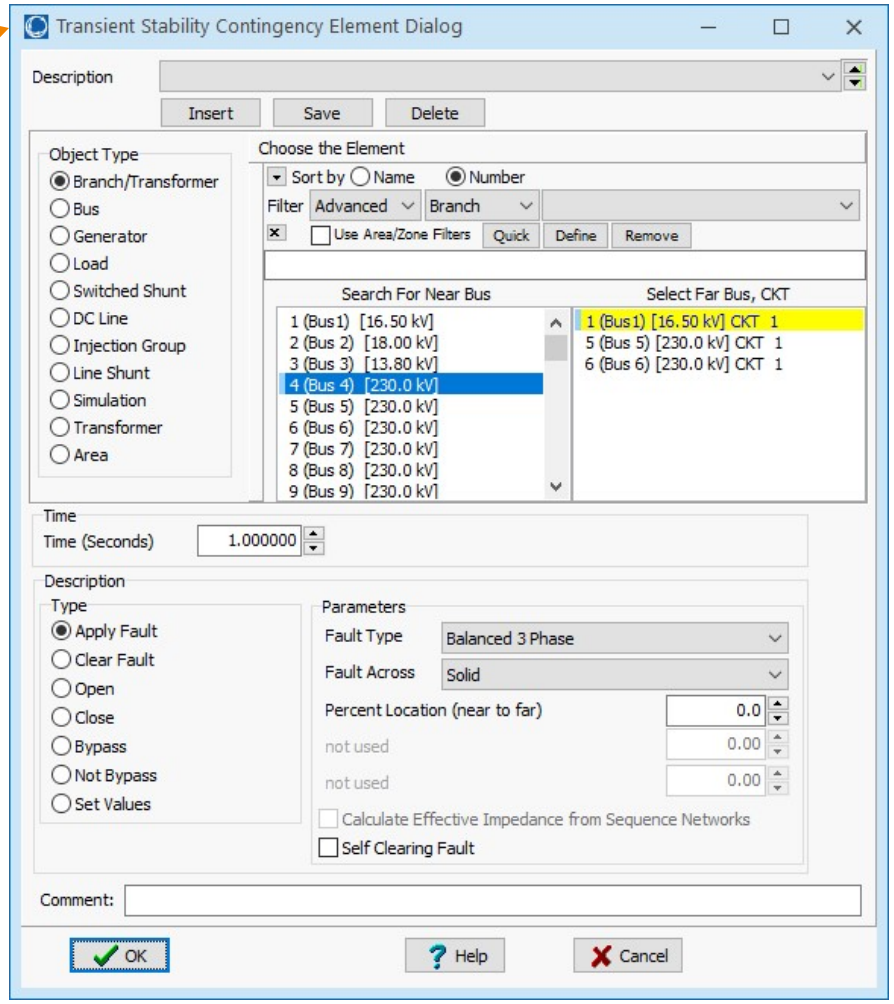
- Bus
  - Apply Fault
    - Apply the specified fault type (Balanced 3 phase, Single Line to Ground, Line to Line, or Double Line to Ground)
    - Fault Across – (Solid, with Impedance and specifying PU Resistance and PU Reactance, or with Admittance specifying PU Conductance and PU Susceptance)
  - Clear Fault
- Generator
  - Open the generator.
  - Close the generator.
  - Ramp Values : Output , Exciter Setpoint (Vref), Governor Setpoint (Pref) Set Values
  - Set Value: Output , Exciter Setpoint (Vref), Governor Setpoint (Pref)
- Load
  - Open
  - Close
  - Set Values

Transient Contingency Element Actions Types

- Switched Shunt
  - Open
  - Close
- AC Line/Transformer
  - Apply Fault
    - Apply the specified fault type (Balanced 3 phase, Single Line to Ground, Line to Line, or Double Line to Ground)
    - Fault Across – (Solid, with Impedance and specifying PU Resistance and PU Reactance, or with Admittance specifying PU Conductance and PU Susceptance)
    - Percent Location
  - Clear Fault
  - Open : Both Ends, From End Only, To End Only, One Phase Open
  - Close : Both Ends, From End Only, To End Only
  - Bypass, and Not Bypass: intended for series capacitors
- DC Line
  - Open

Creating Transient Contingency Elements

- Click **Insert Elements**, or Choose **Records, Insert** → Opens the Transient Contingency Element Dialog
- Transient Contingency Elements involve specifying the following:
  - Object element is applied to
  - Time element occurs
  - Event Type
  - Parameters for element



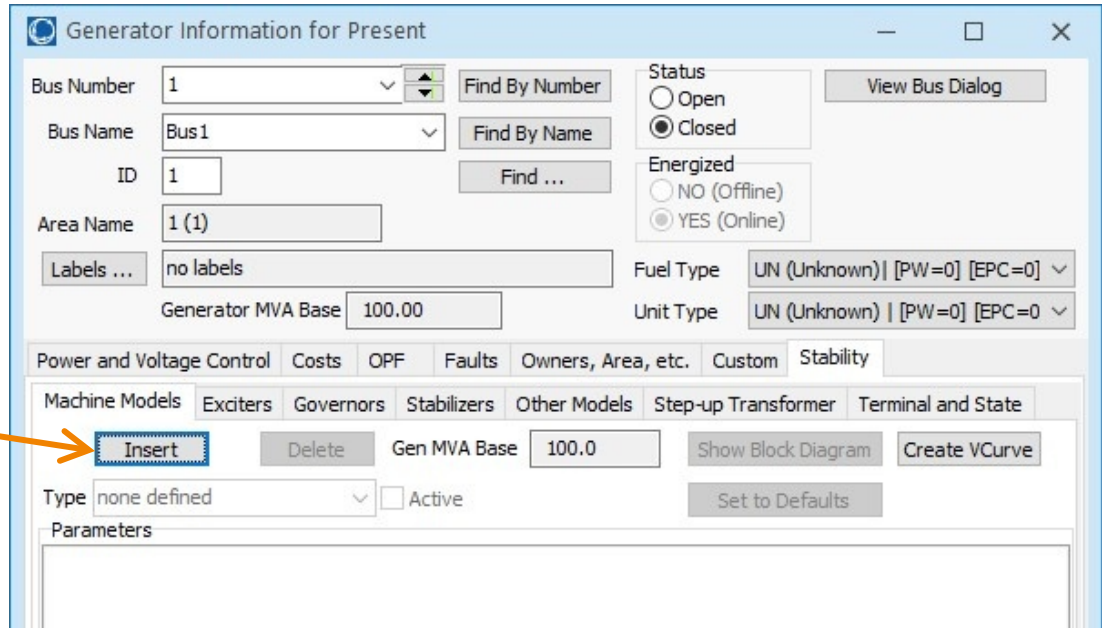
TS9Bus Example

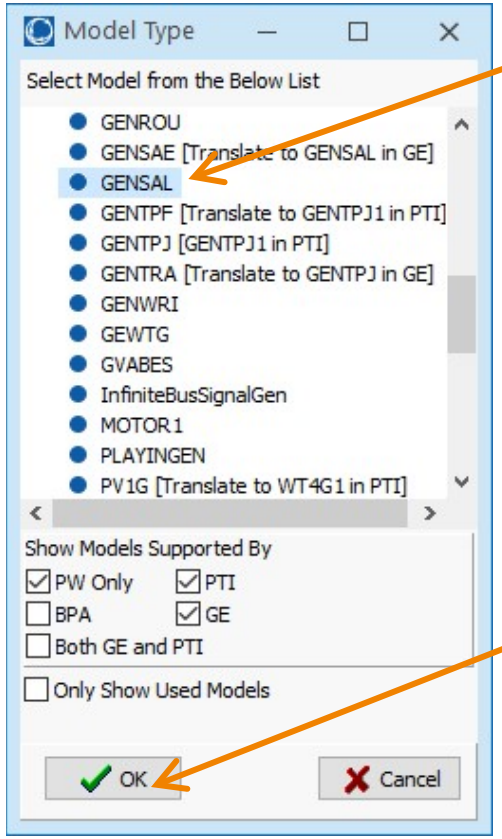
- Open TS9BusNoModels.pwb
- With PowerWorld Simulator, a power flow case can be quickly transformed into a transient stability case
  - This requires the addition of at least one dynamic model
- We will now go through how to transform a power flow case into a transient stability case
- Add a dynamic generator model to an existing “no model” power flow case by:
  - In run mode, right-click on the generator symbol for bus 1, then select “Generator Information Dialog” from the local menu
  - This displays the Generator Information Dialog, select the “Stability” tab to view the transient stability models; none are initially defined.

Inserting a Model

- From the Generator Information Dialog, insert a GENSAL model (represents a salient pole machine)

Click to insert a machine model





Choose GENSAL

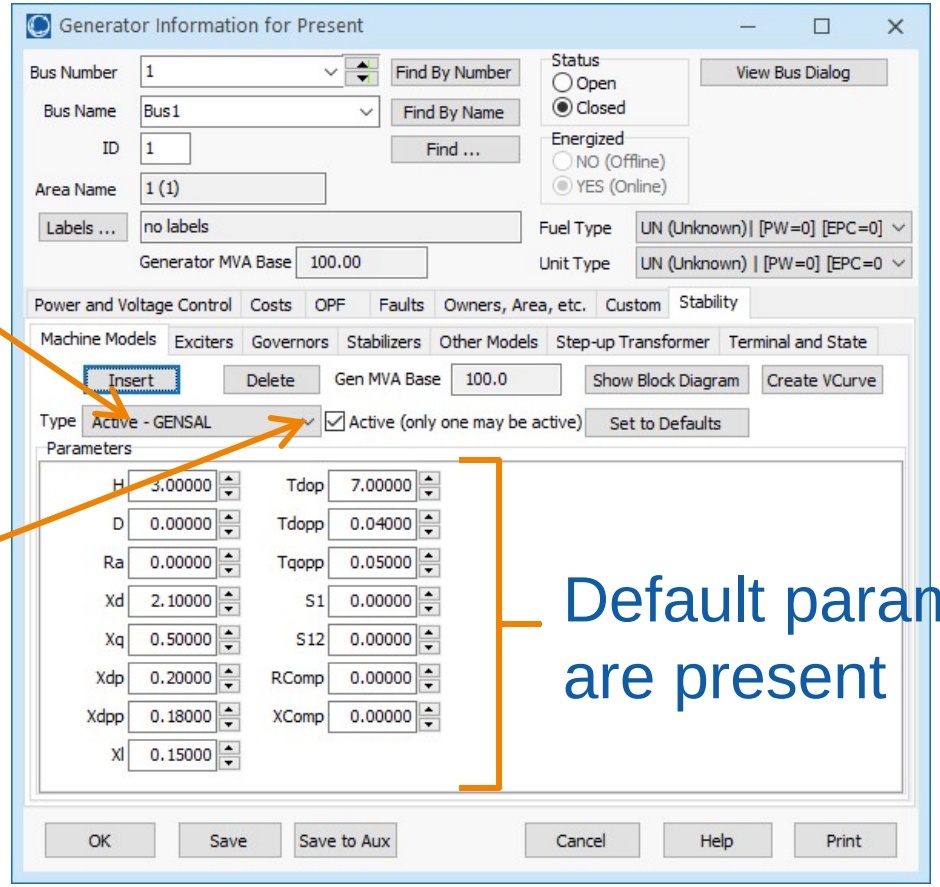
Click "OK"

Inserting a Model

- GENSAL Dialog for Bus 1 now looks like this-

GENSAL is the only machine model inserted for this generator, so it was automatically made active

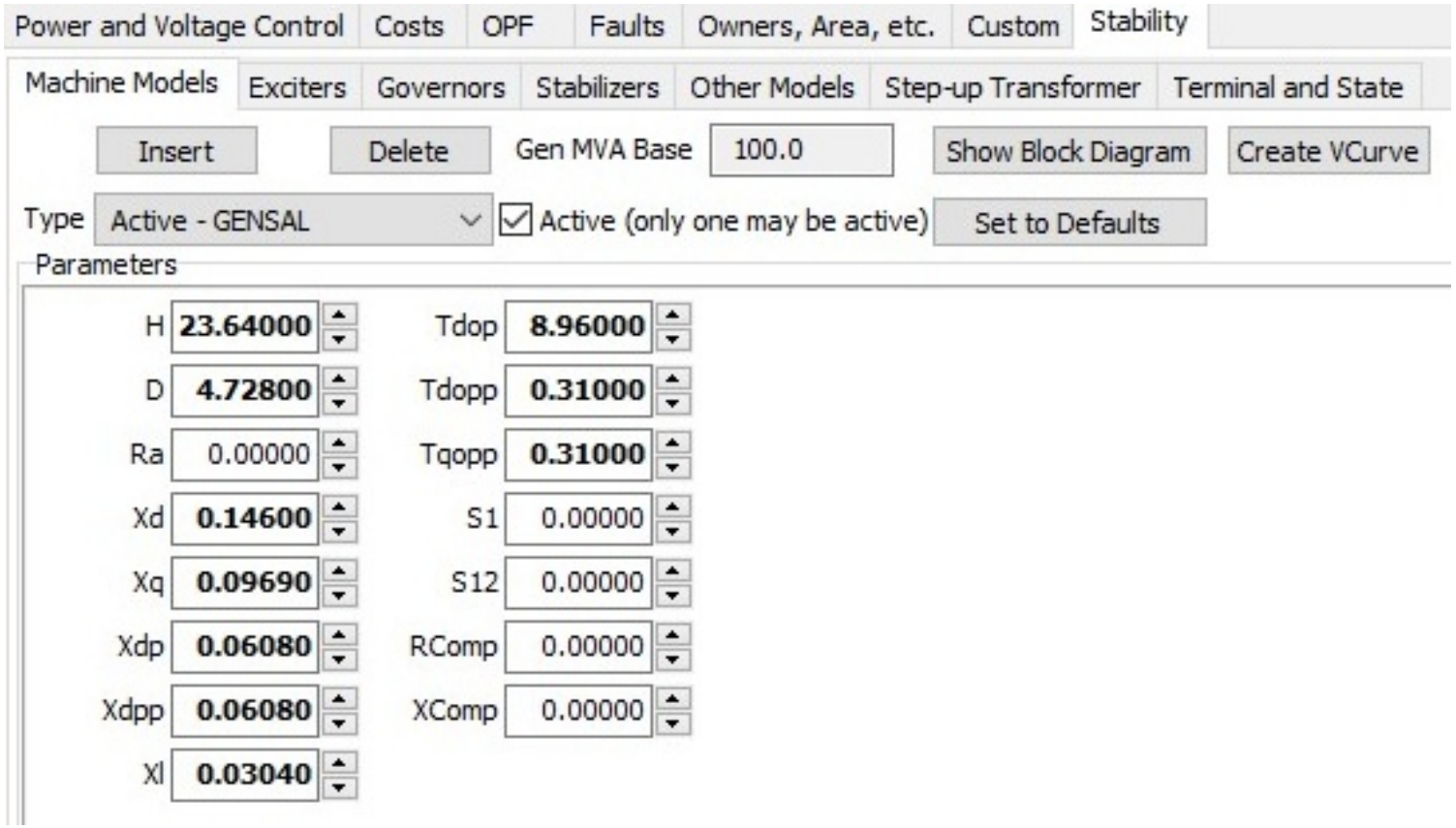
If you add more models, you need to select which to make active



Default parameters are present

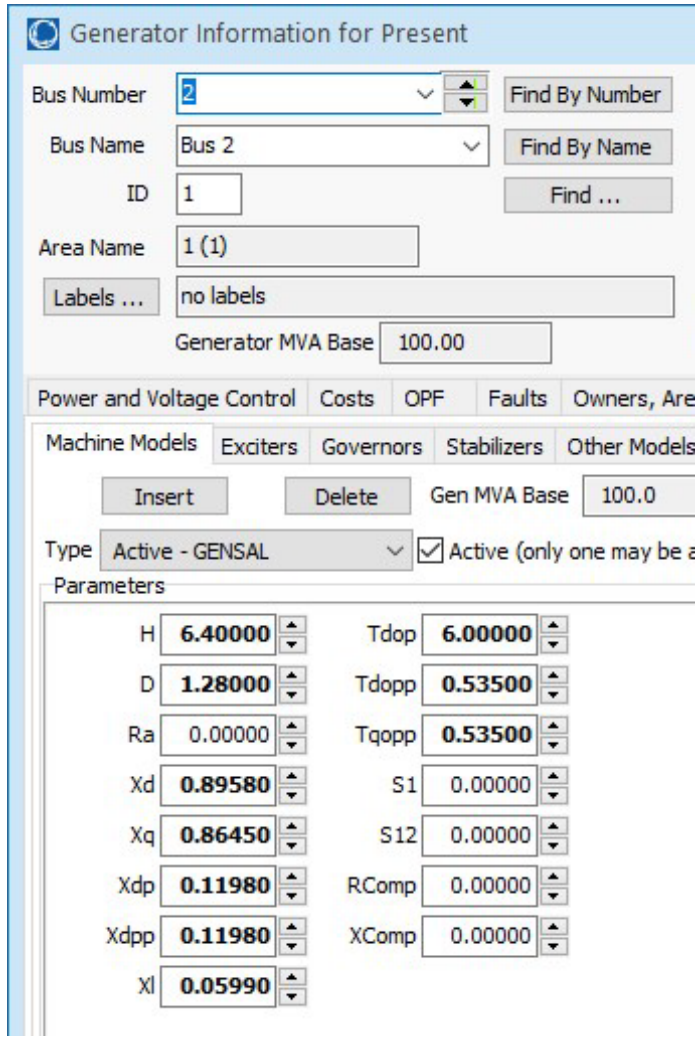
Inserting a Model

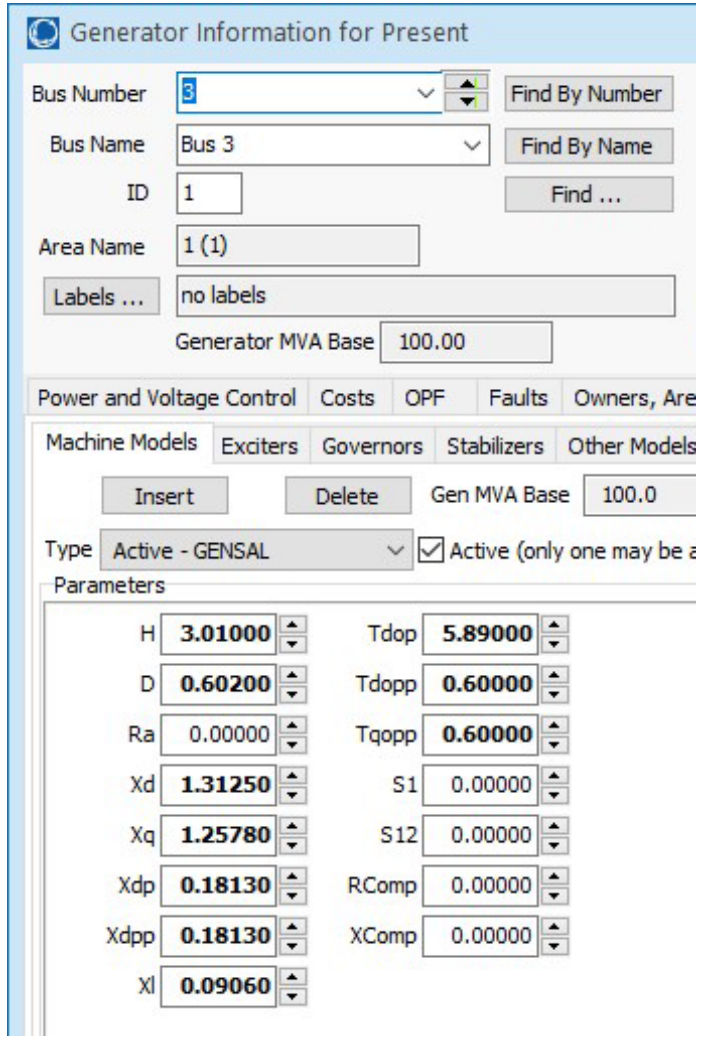
- Modify the machine parameters at Bus 1 to match those shown here



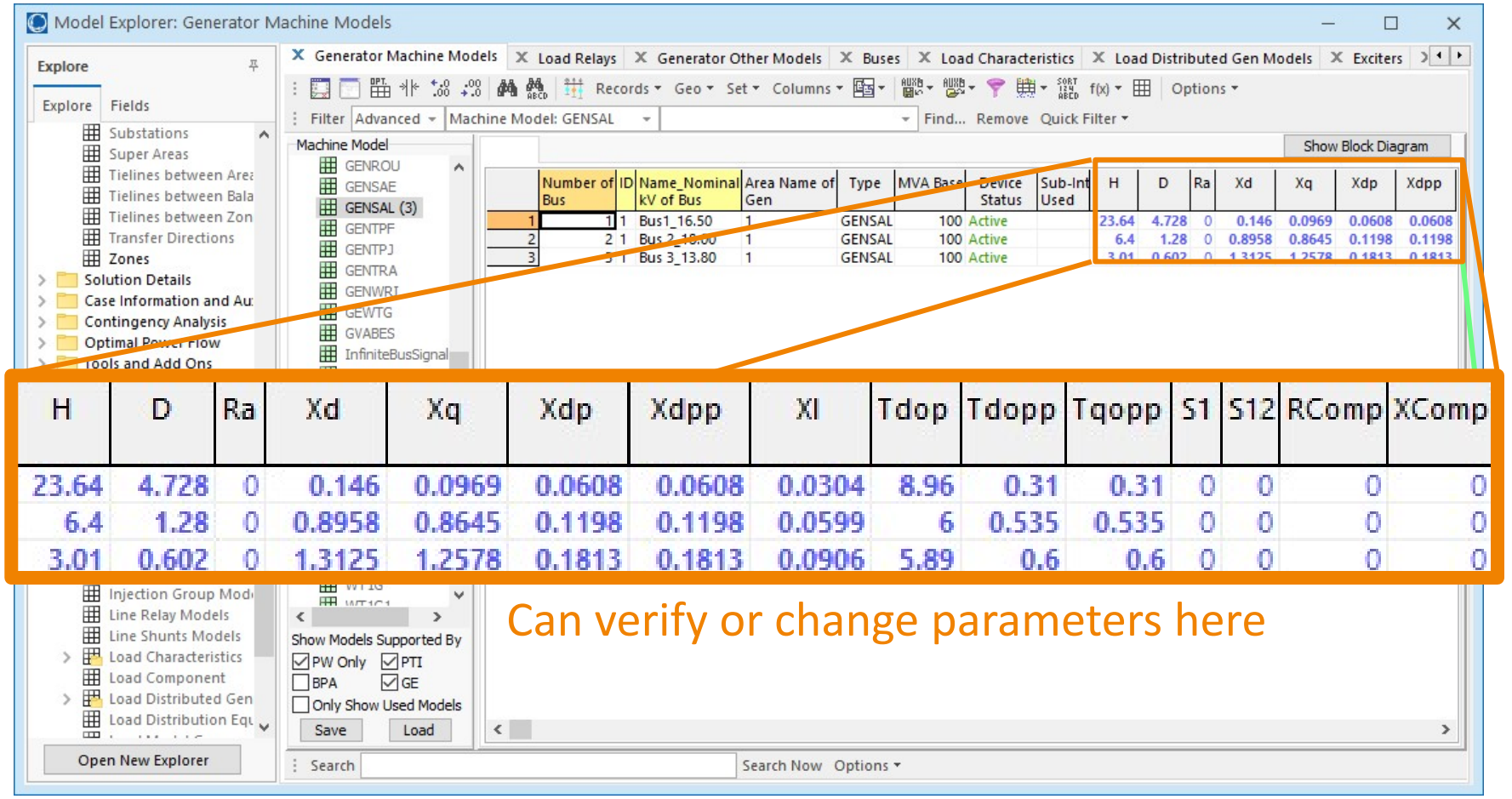
Inserting a Model

- Repeat for Generators 2 and 3





Model Explorer – Machine Models



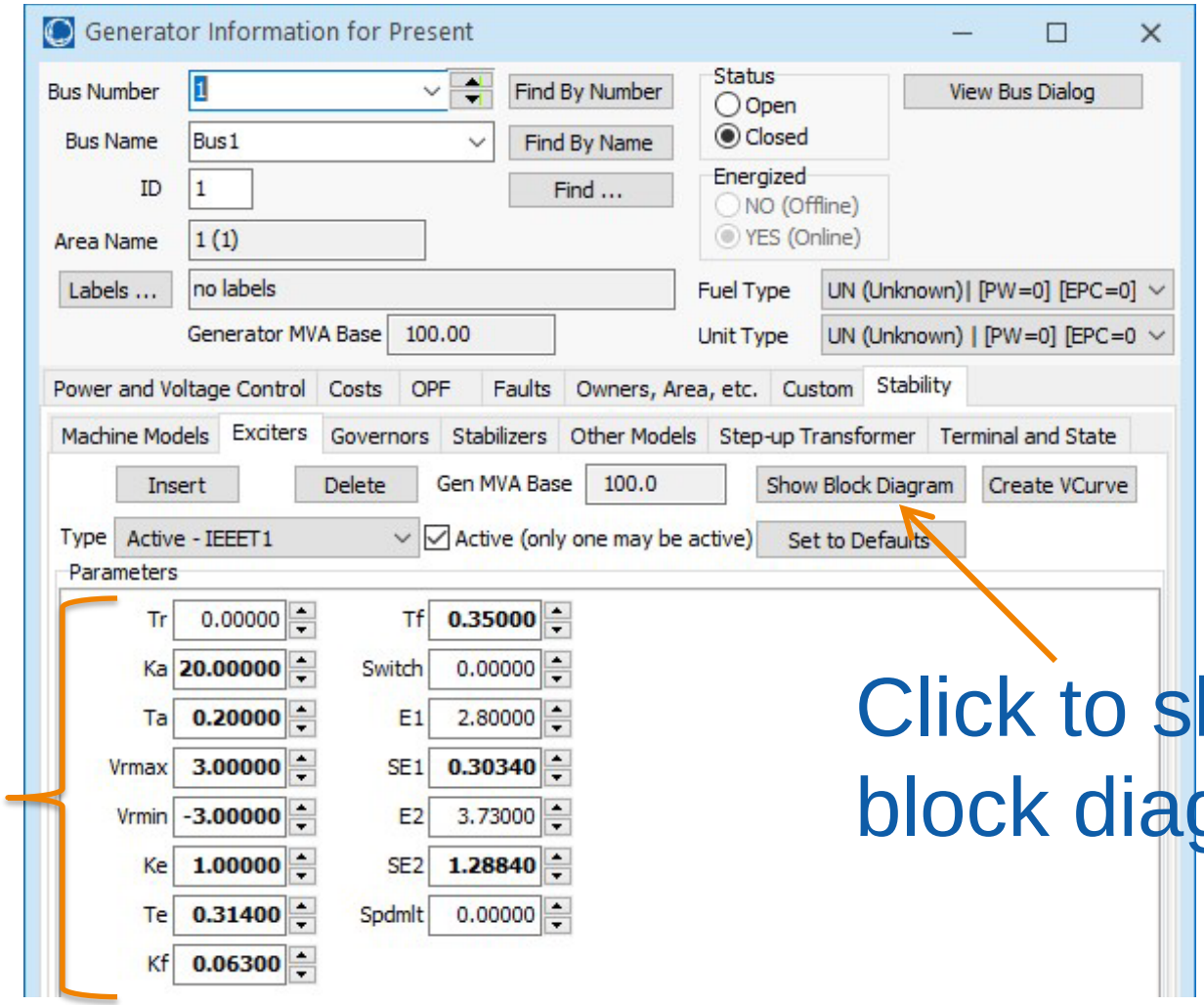
Adding a Generator Exciter

- The purpose of the generator excitation system (exciter) is to adjust the generator field current to maintain a constant terminal voltage.
- PowerWorld Simulator includes many different types of exciter models. One simple exciter is the IEEET1. To add this exciter to the generator dialog, “Stability” tab, “Exciters” page. Click Insert and then select IEEET1 from the list.
- The IEEET1 is by far the most common exciter used in the 2006 MMWG case; the next most common is its close relative, the IEEEX1.

Insert Exciter Models

Add IEEET1 Exciter models to all three generators

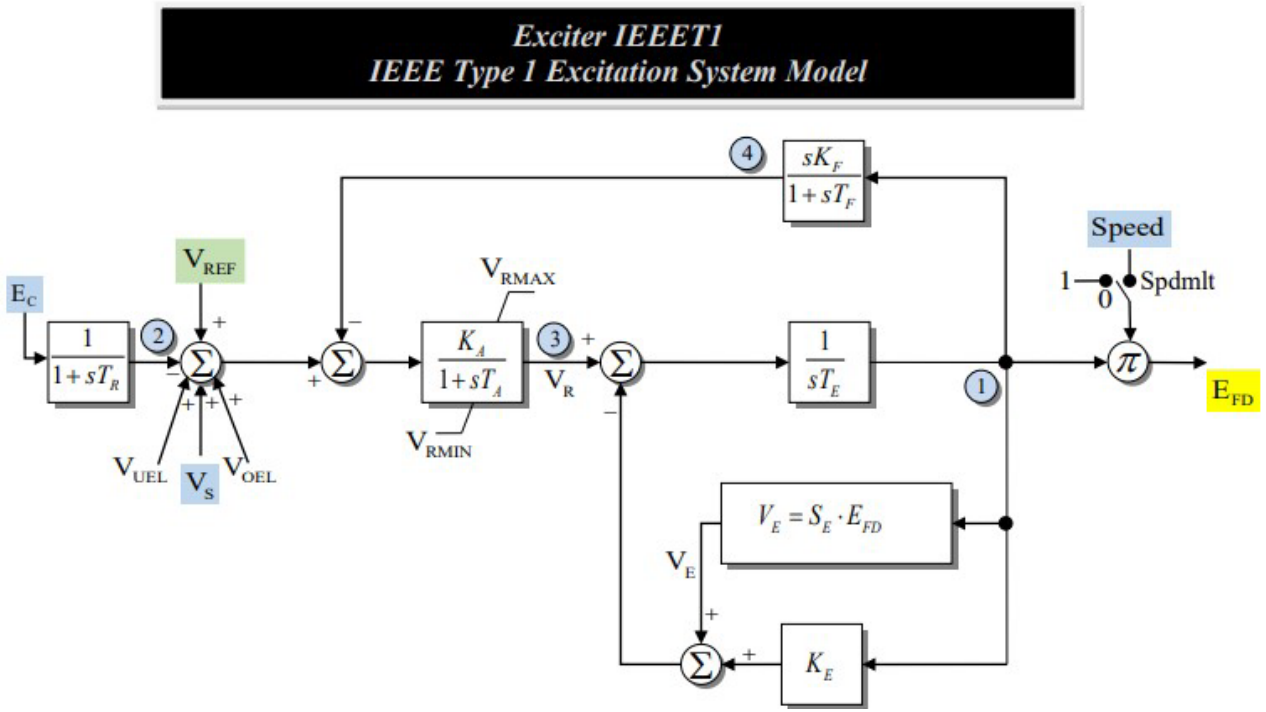
Change settings for all three exciters to match these



Click to show block diagram

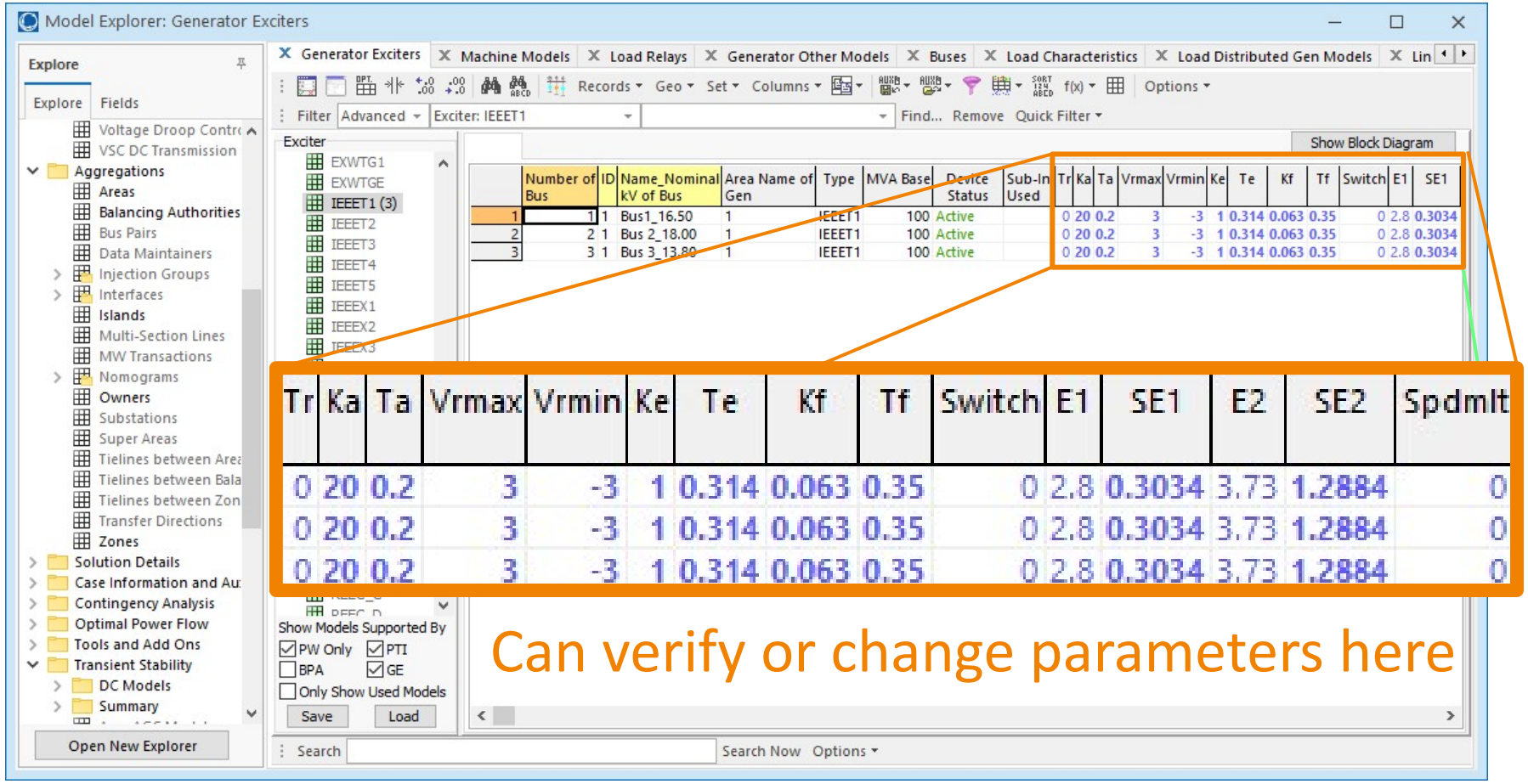
IEEET1 Exciter

- You can view the block diagram for the IEEET1 exciter by clicking on the "Show Diagram" button.
- This opens a PDF file in Adobe Reader to the page with the appropriate block diagram (shown below).

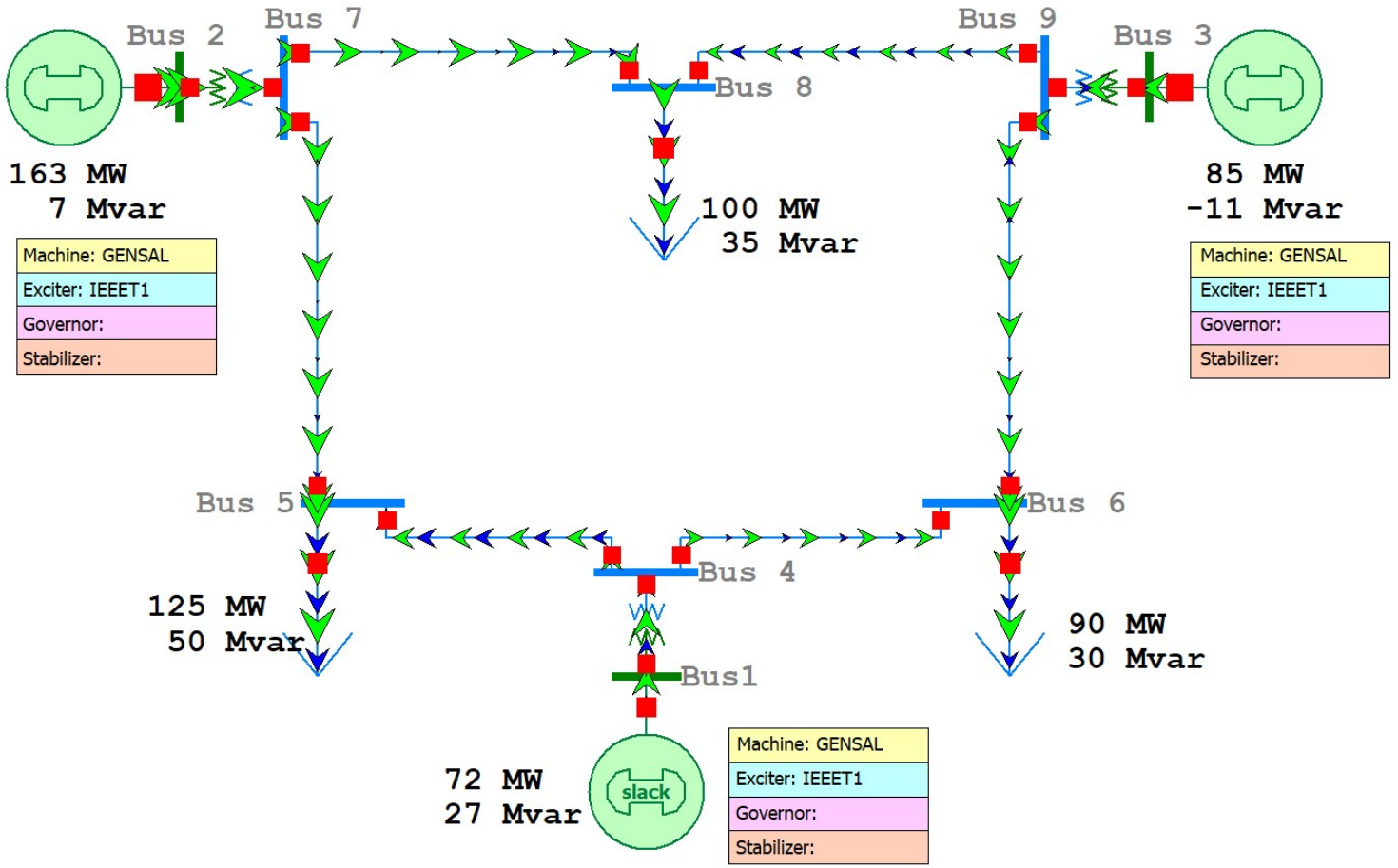


The input to the exciter, E_c, is usually the terminal voltage. The output, E_{FD}, is the machine field voltage.

Model Explorer - Exciters

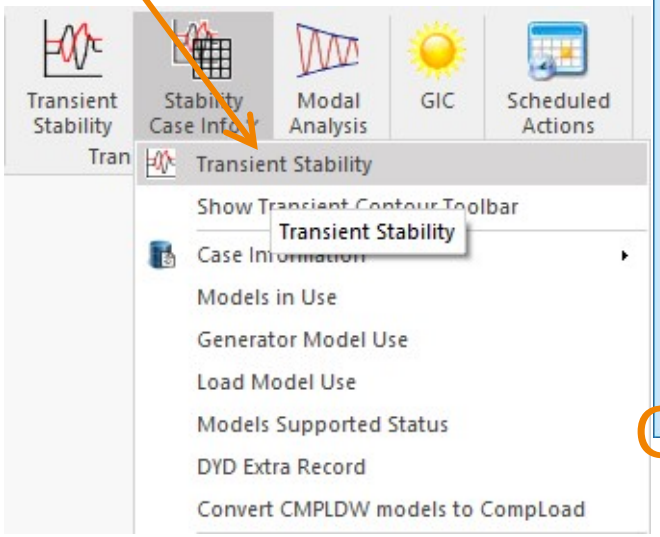


TS9Bus System with Machine and Exciter Models

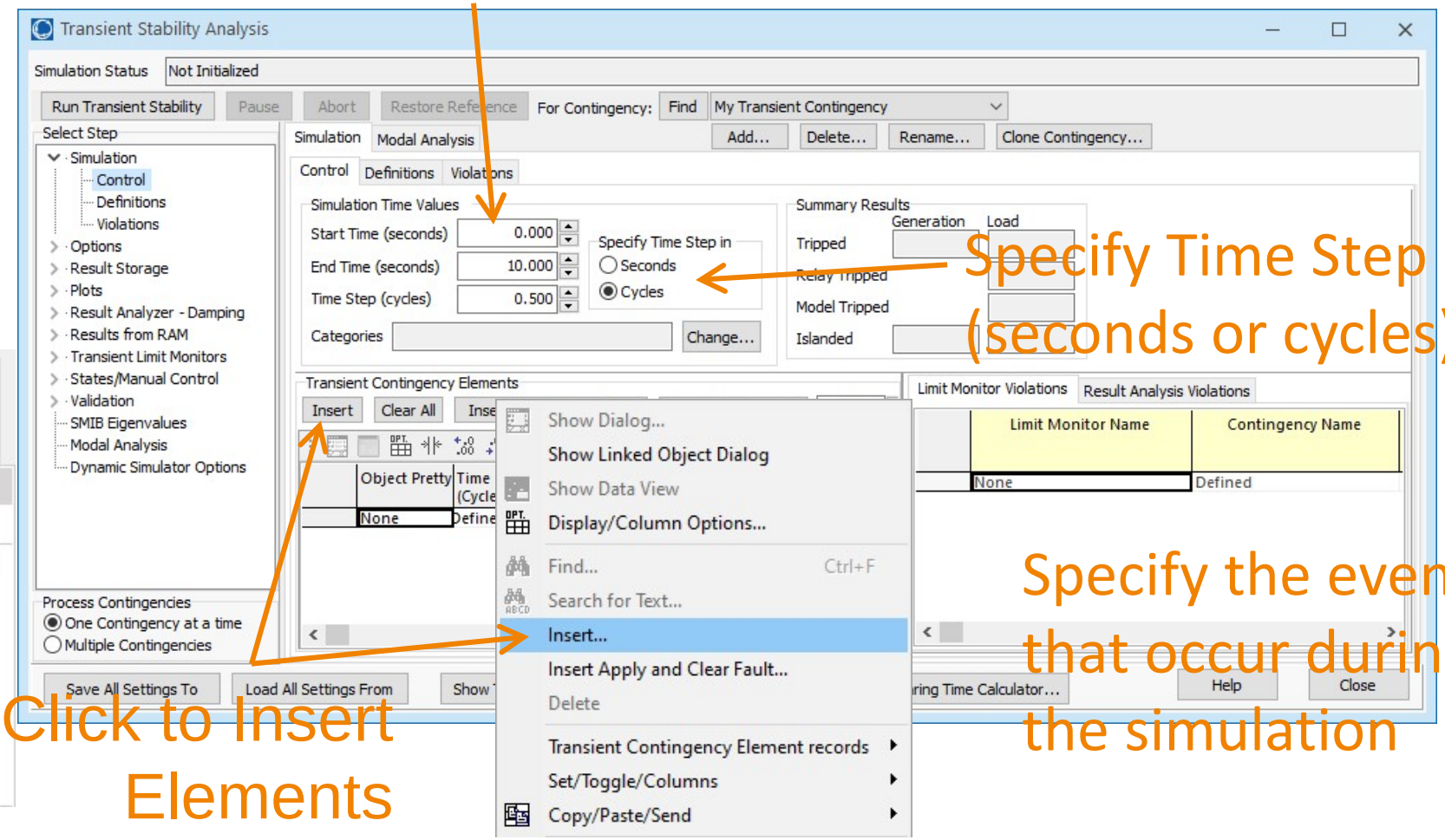


Define a Transient Contingency

Go to the **Add Ons** ribbon tab and select **Transient Stability**



Specify Start and End Time



Specify Time Step (seconds or cycles)

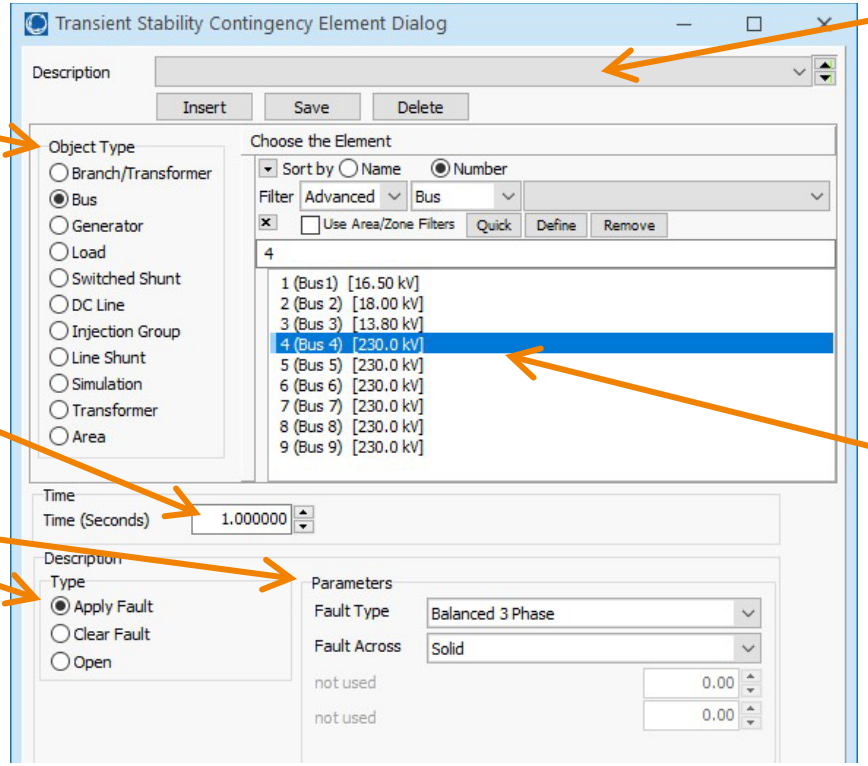
Specify the events that occur during the simulation

Click to Insert Elements

Transient Stability Contingency Element Dialog

- Clicking “Insert” opens the Transient Stability Contingency Element Dialog shown below
- This dialog is used to specify transient stability events and when they occur

No events have been defined yet



Object Type

- Changes the type of events that can occur

Time

- When the event occurs

Event Type and Parameters

- Depends on Object Type

Description

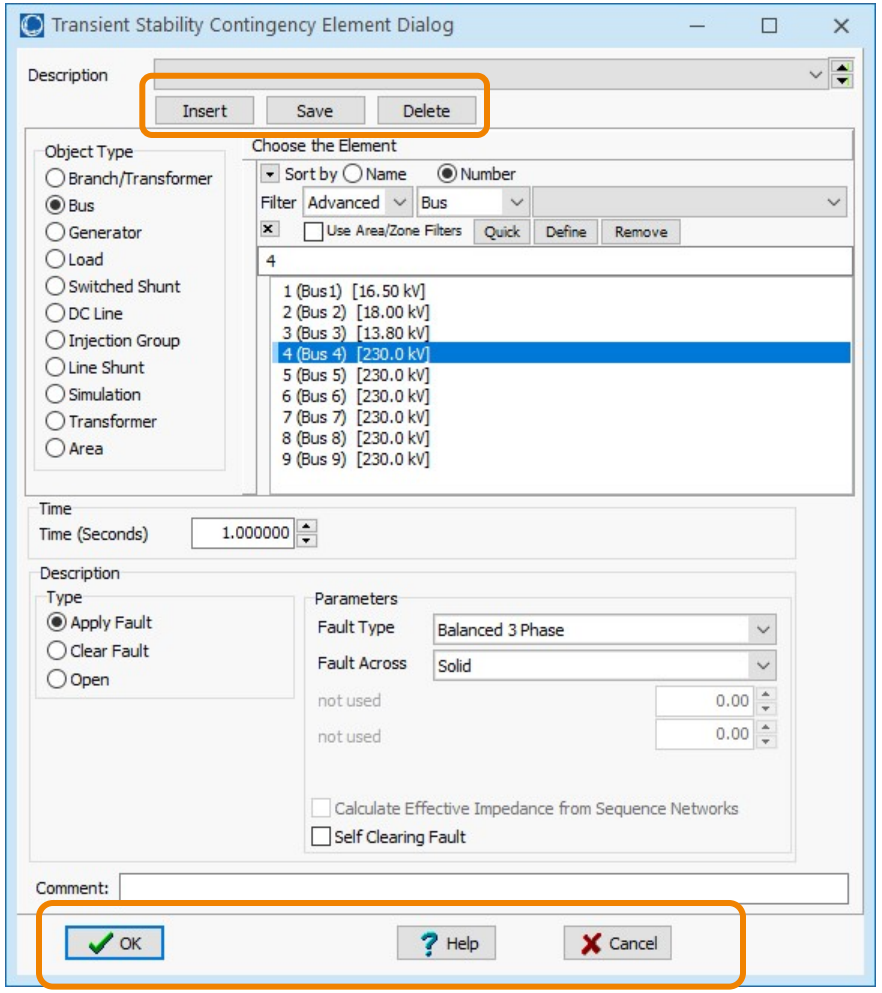
- A drop-down list of all currently defined events
- May be used to switch between events and modify them as necessary
- Appears once the event is saved

Choose the Element

- Apply the event to this element
- List is updated as Object Type is changed

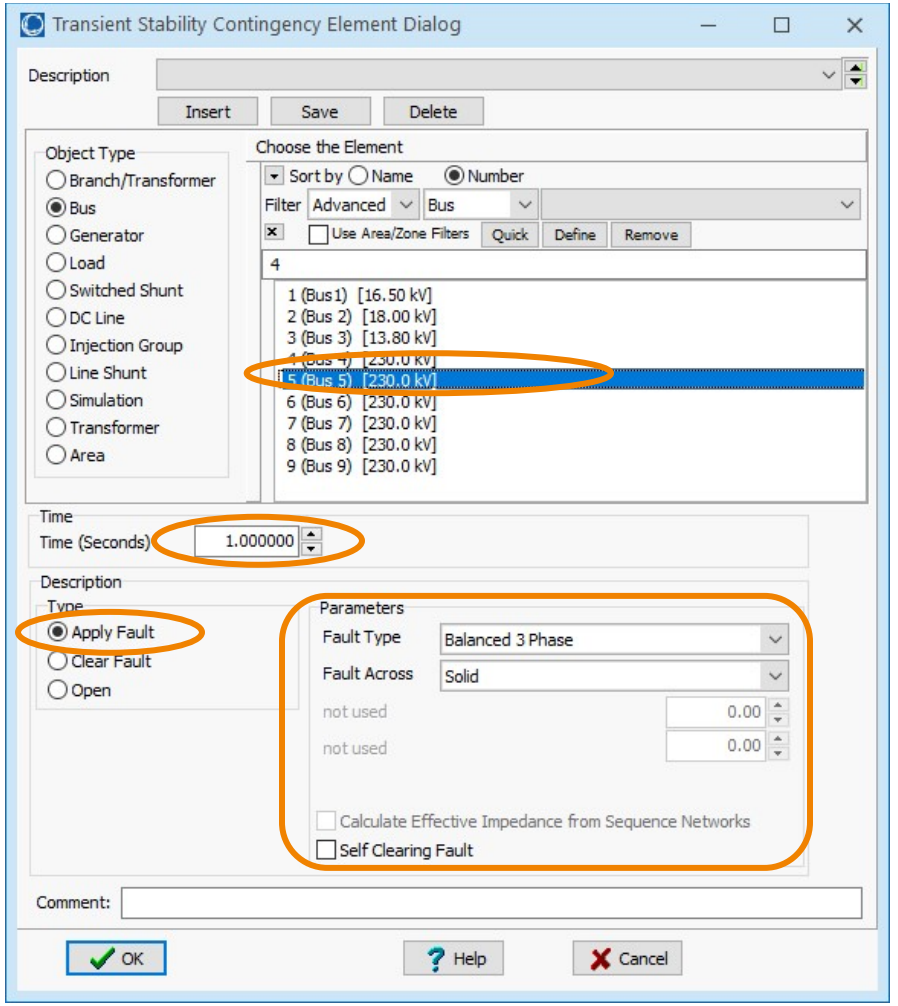
Transient Stability Contingency Element Dialog

- “Save” will save any modifications but leave the dialog open
- “Insert” creates a new event with the specified parameters
- “OK” will accept changes and close the dialog
- “Delete” will delete the event defined by the event Description
- “Cancel” closes the dialog without saving



Add a Fault at Bus 5

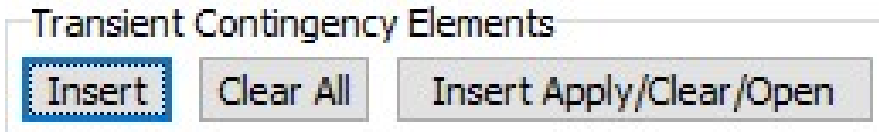
- Apply a balanced solid three-phase fault on Bus 5 at time = 1.00 seconds

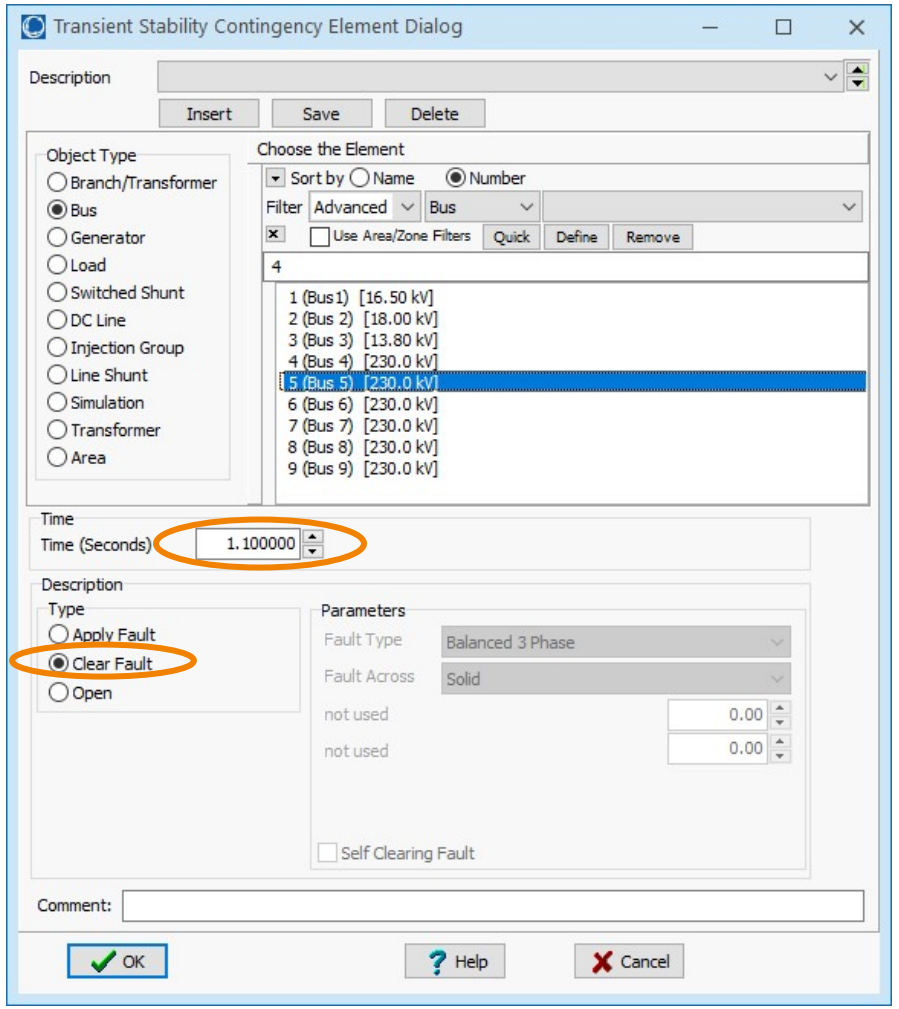


Clear Fault at Bus 5

- Clear the Bus 5 fault at time = 1.10 seconds

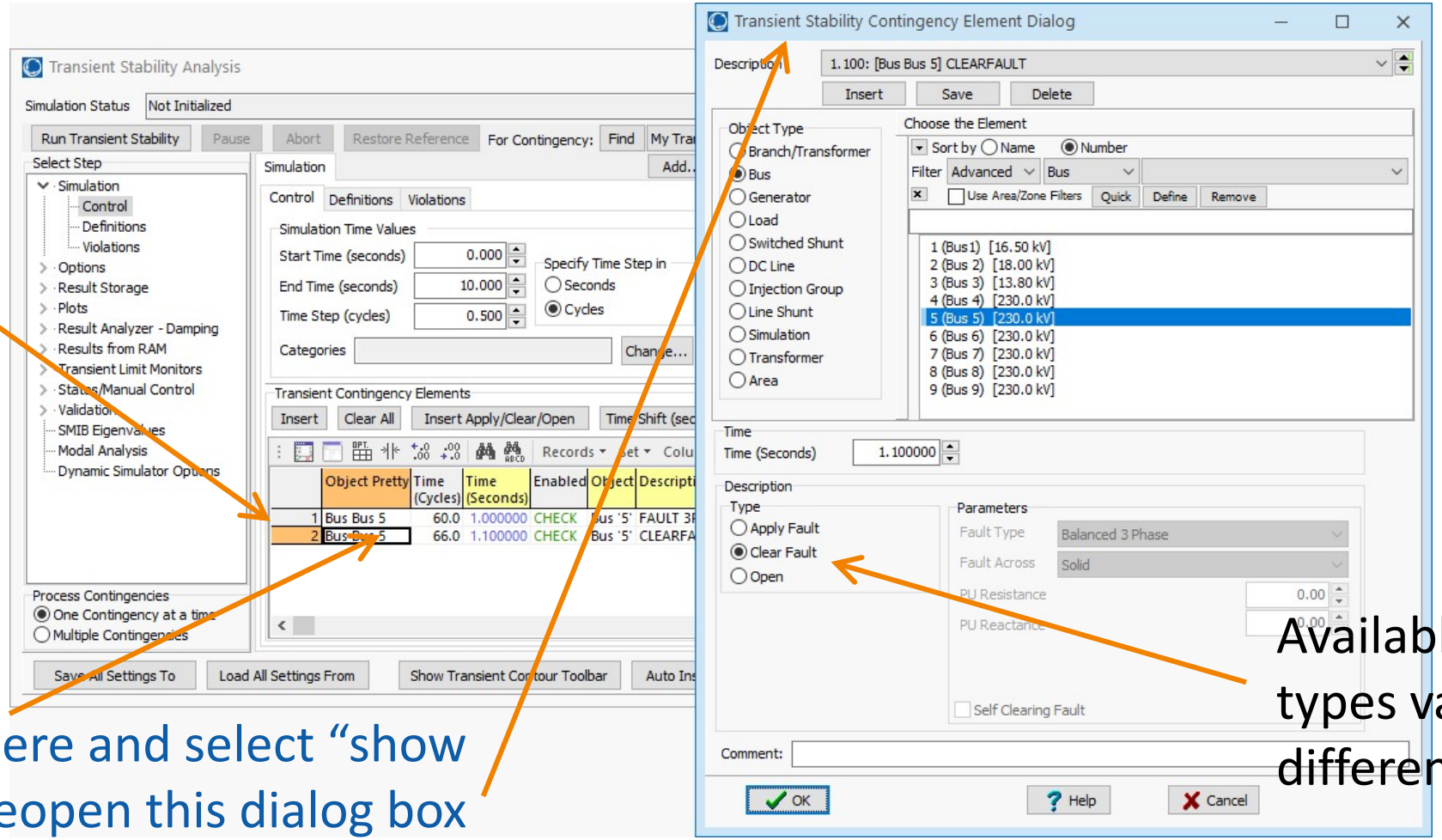
Note: could have also used the **Insert Apply/Clear/Open** button





Transient Contingency Definition

Summary of all elements in contingency and time of action

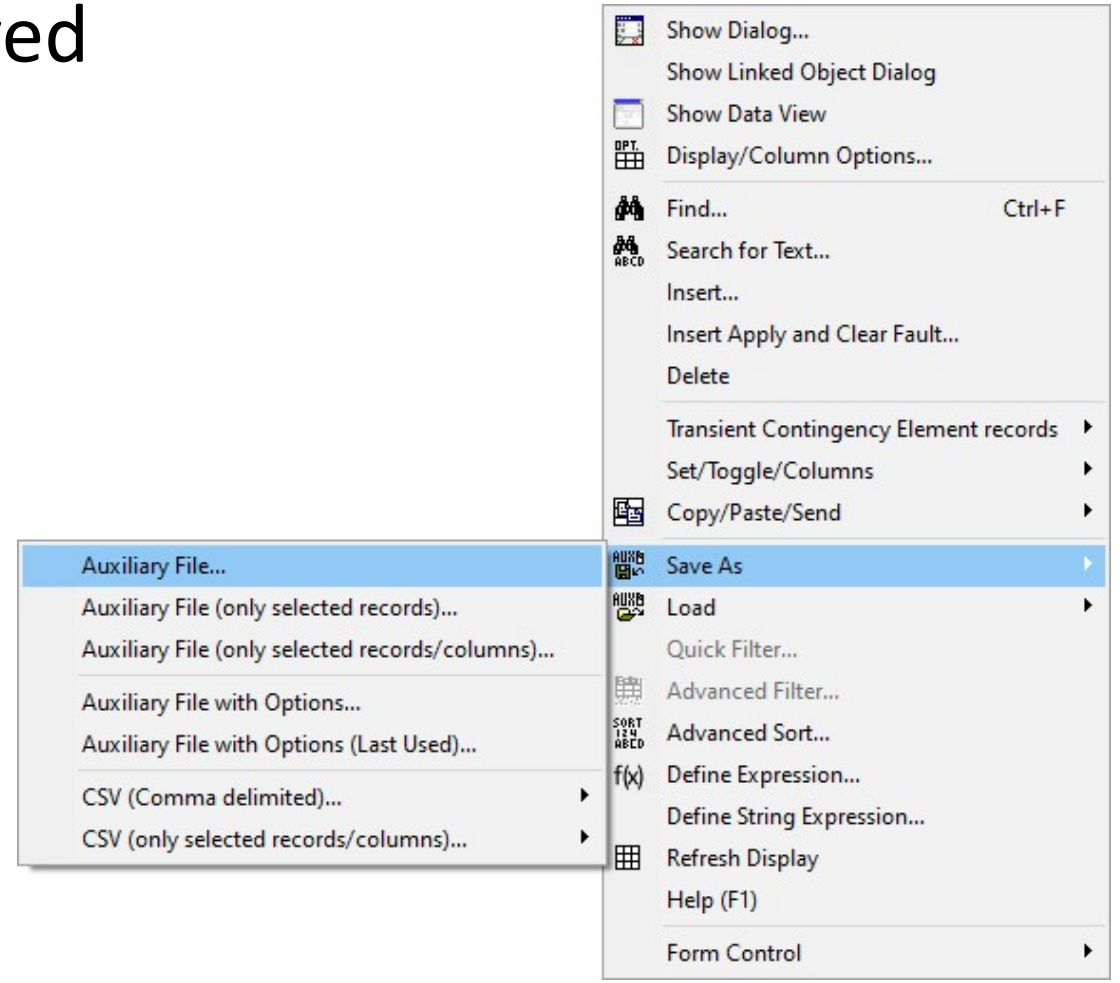


Right click here and select “show dialog” to reopen this dialog box

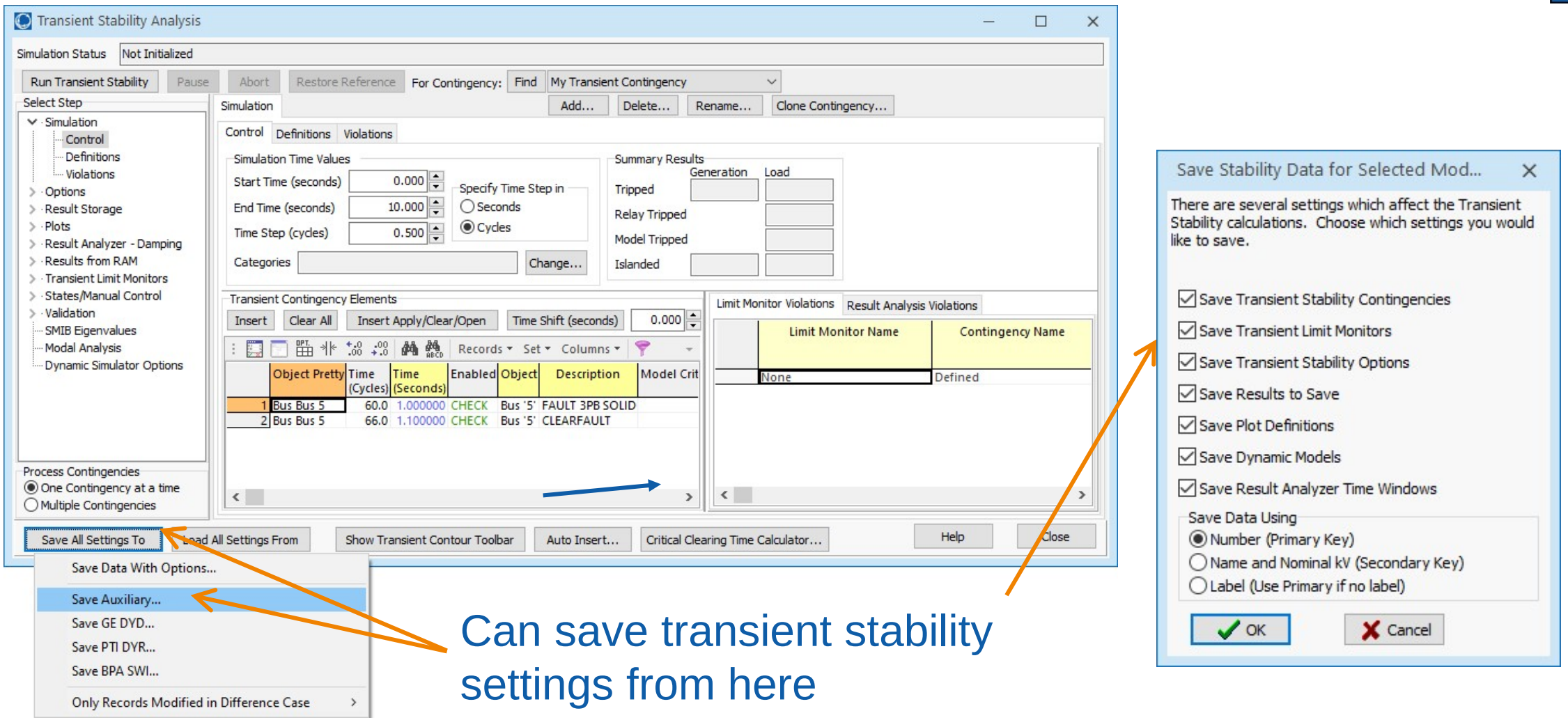
Available element types vary with different objects

AUX files to Save/Load Model Data

- Any of the model data can be saved into AUX files
- Save machine model data-
  - Right click in Model Explorer
  - Select “Save As” “Auxiliary File…”
- This data can be loaded back in



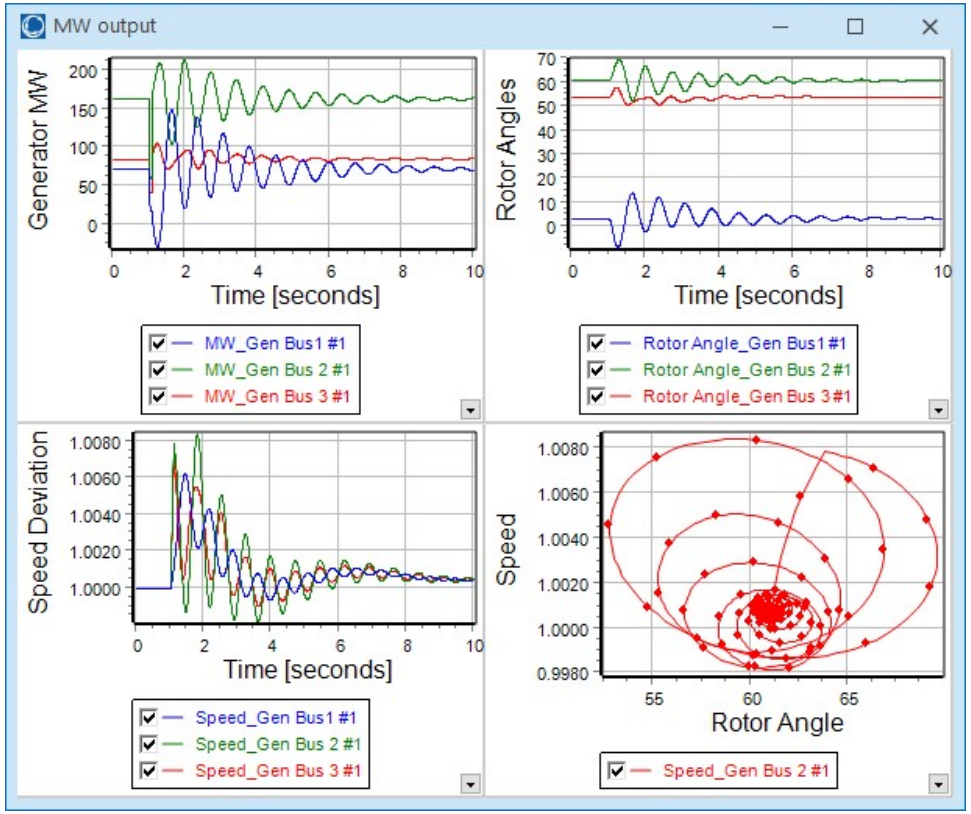
Save Stability Settings



Can save transient stability settings from here

Load in Plot Settings

- The machine models and exciter models for this example can also be loaded in from TS9ExciterModels.aux and TS9MachModels.aux
- Save the case with the models and events as TS9Bus Bus Fault NoPlot
- Go to Stability Case Info, Load Transient Stability Data, Load Auxiliary
- Load in the AUX file TS9Bus Bus FaultPLOTDEFN.aux which contains some plot settings that we will talk about in detail in a later section
- Save the case as TS9BusCtgEx
- Click “Run Transient Stability” to simulate the models and the events that you inserted



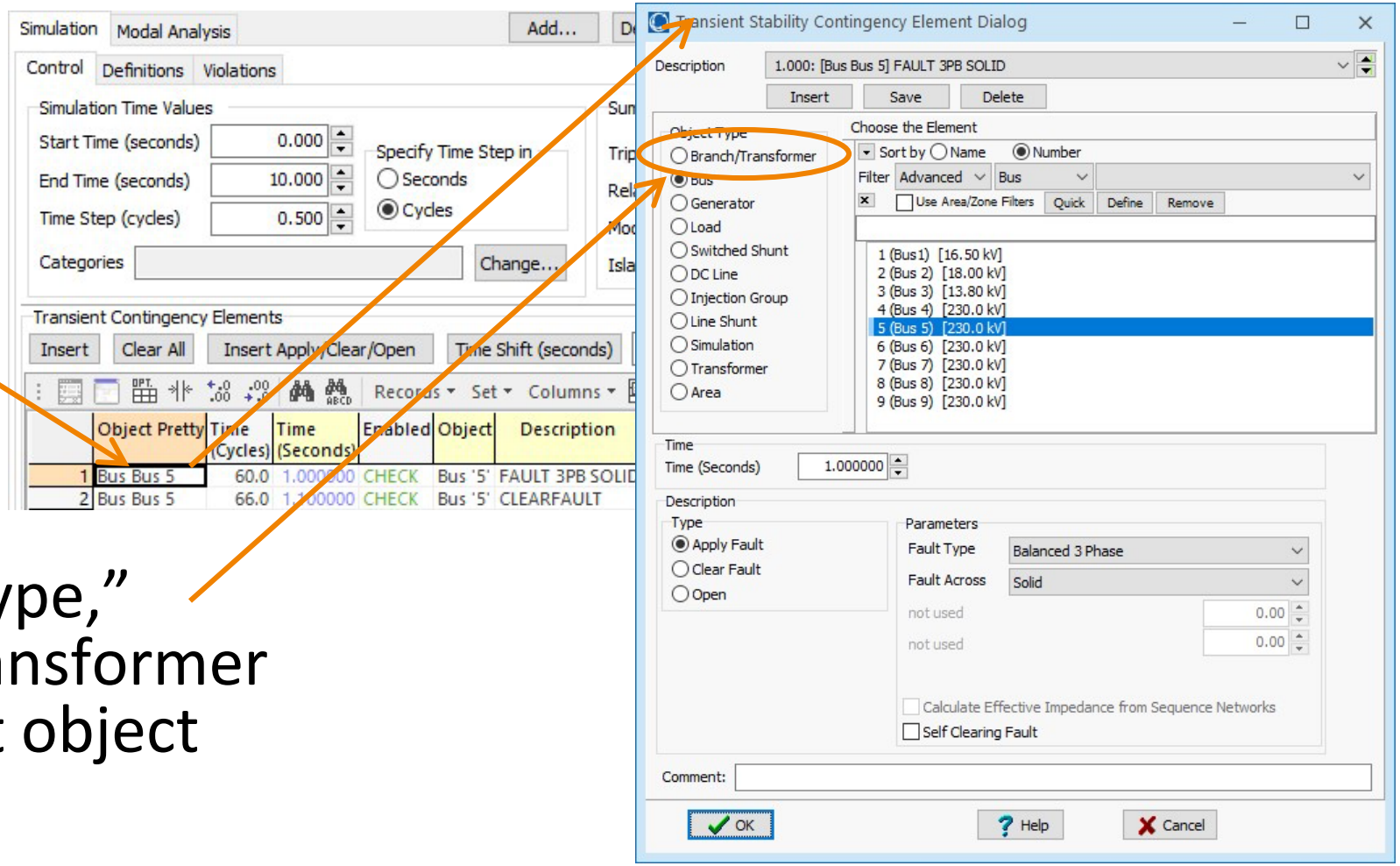
Example: Changing Contingency Elements

- Suppose you want to change the events that are simulated for a particular contingency
- We will change the elements of this Transient Contingency from a bus fault at Bus 5 to a fault between Bus 4 and Bus 5 near bus 5
- There are several ways this can be done
  - On the Simulation page, clicking “Clear All Elements” will remove the existing elements; you can then add new ones
  - You can right-click on an existing element and open the Transient Contingency Element Dialog and change the events directly

Example: Changing Contingency Elements

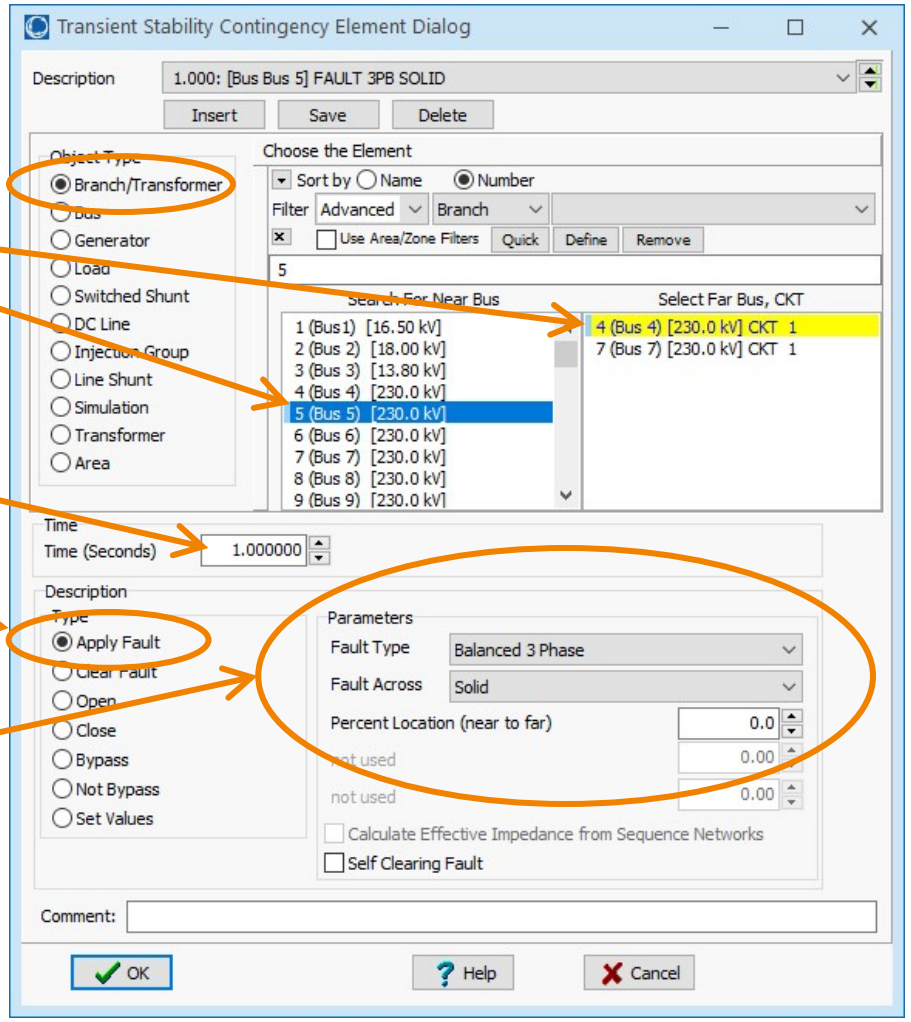
Right-click on the first Transient Contingency Element and open the Transient Stability Contingency Element dialog

First, change “Object Type,” from Bus to Branch/Transformer to view choices for that object type



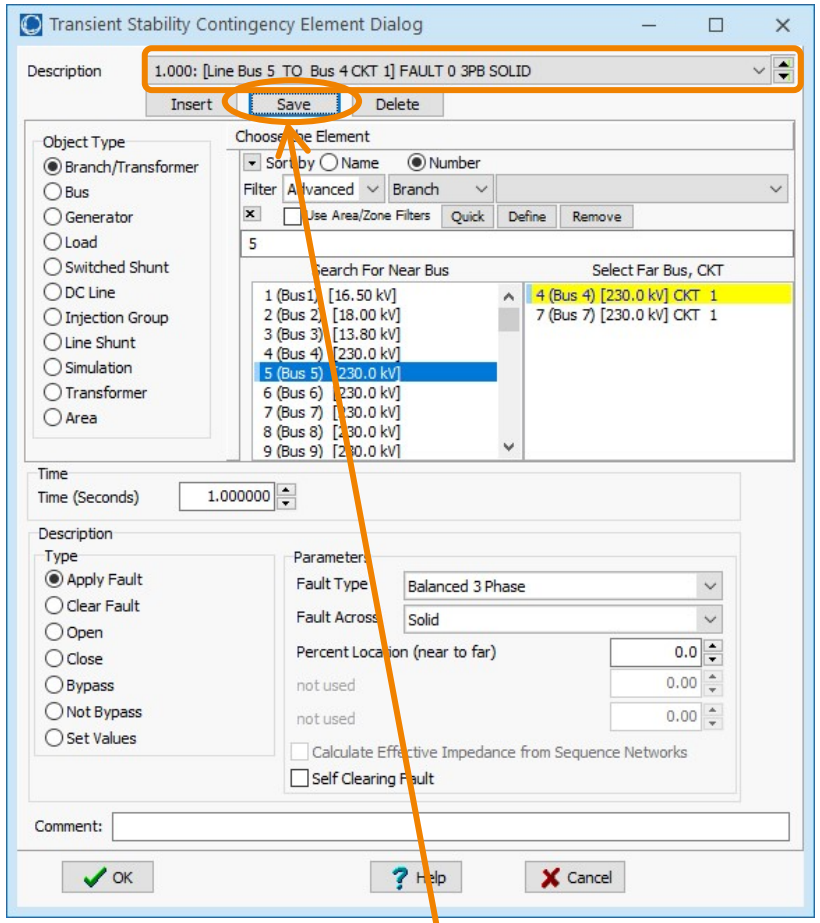
Example: Changing Contingency Elements

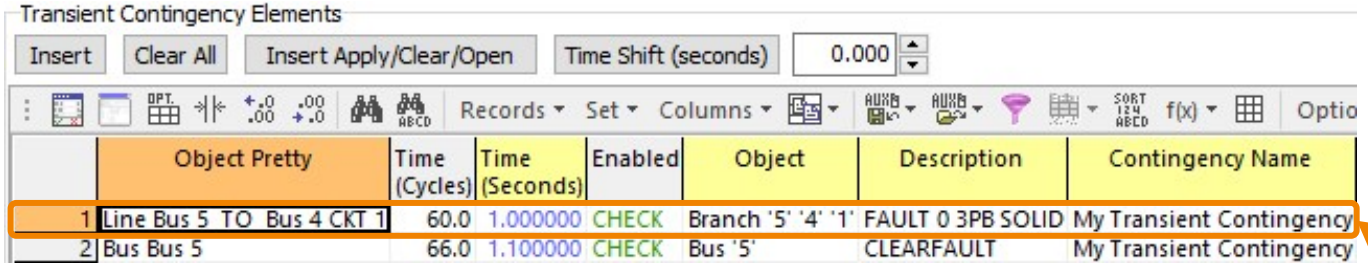
- "Choose the Element"
  - Make sure the Near Bus is selected to be 5 and Far Bus is selected to be 4
- "Time"
  - Time (Seconds) – set to 1.00
- "Description"
  - "Apply Fault" should be selected
- "Parameters"
  - Fault Type – set to Balanced 3 Phase
  - Fault Across – set to Solid
  - Percent Location (near to far) – set to 0.00



Example: Changing Contingency Elements

- After verifying these changes, click “Save”
- Once you click save, the Description at the top changes to reflect that this is now a branch fault
- Then, click OK to close the dialog
- Now the first Transient Contingency Element in the case information display has changed

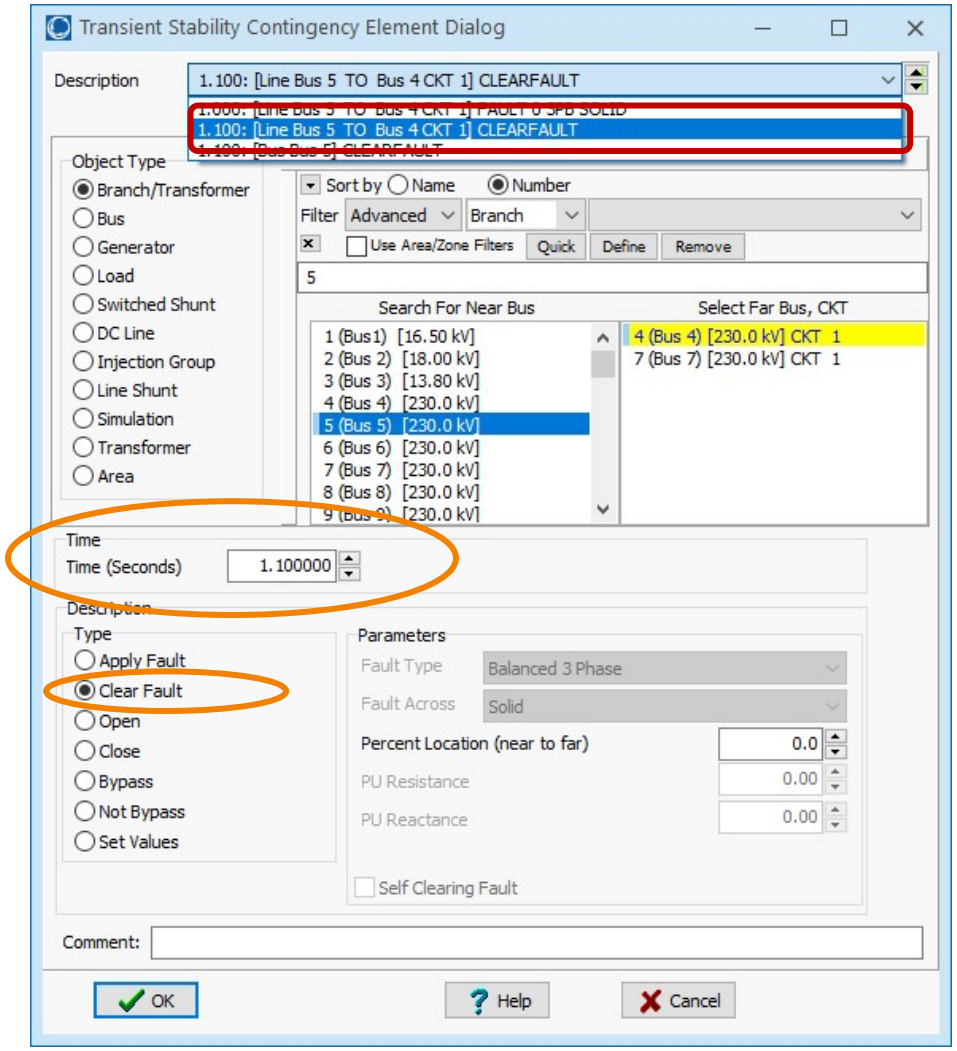




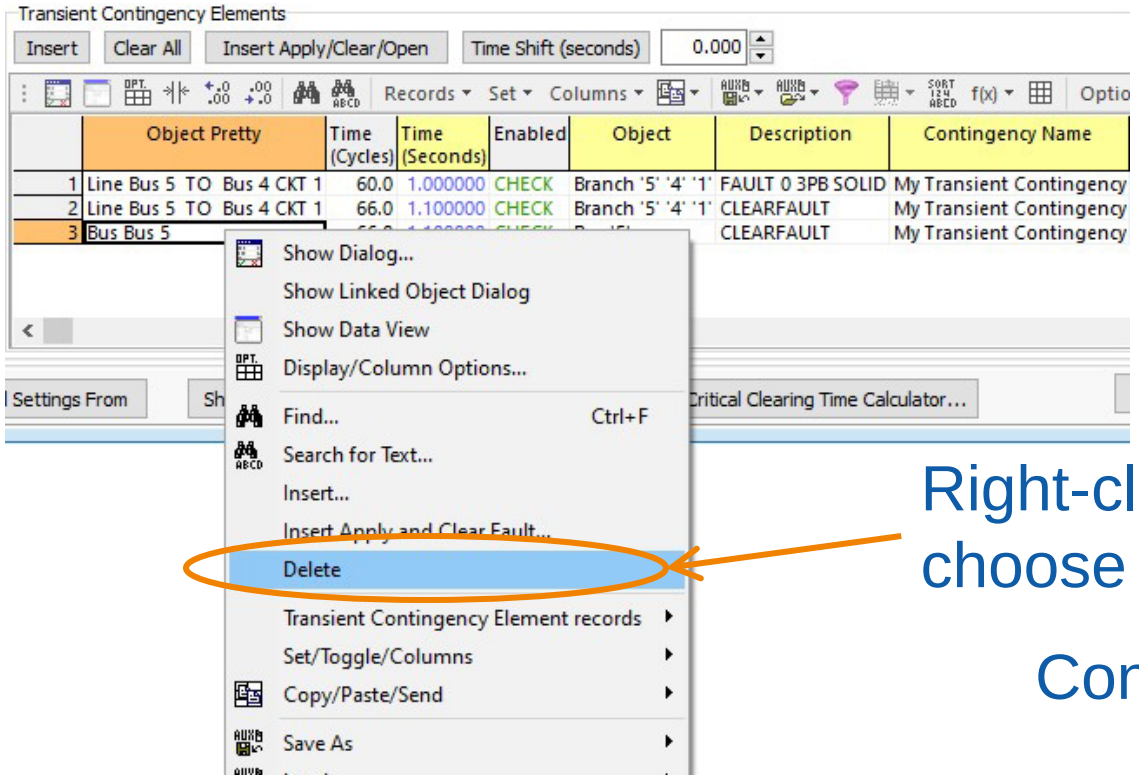
After clicking “Save,” the Description and Case Information Displays will update

Example: Changing Contingency Elements

- Right-click on the second Transient Contingency Element and open the Transient Stability Contingency Element dialog
- From the Description drop-down menu, select the description for the element that you just created
- Change the time to 1.1
- Change Apply Fault to Clear Fault
- All other parameters are unchanged
- Click Insert – a new contingency element with a new name has been created

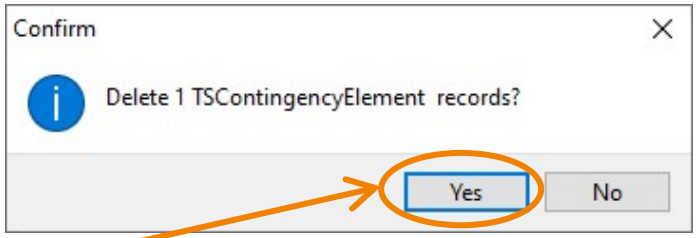


Example: Changing Contingency Elements



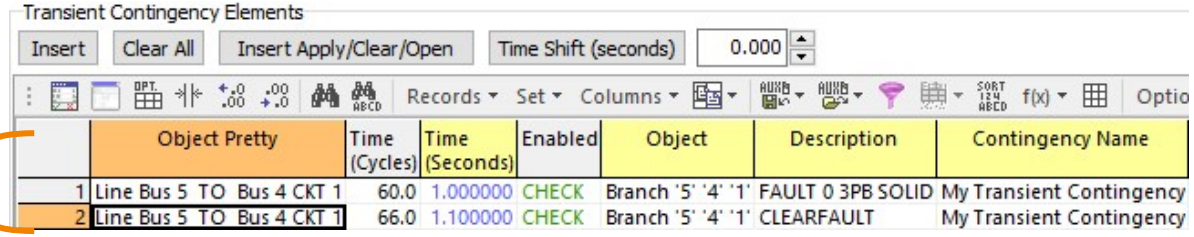
- Click OK to close the dialog
- We still need to delete the third Transient Contingency Element which had been used previously for clearing the Bus 5 fault

Right-click and choose “Delete”



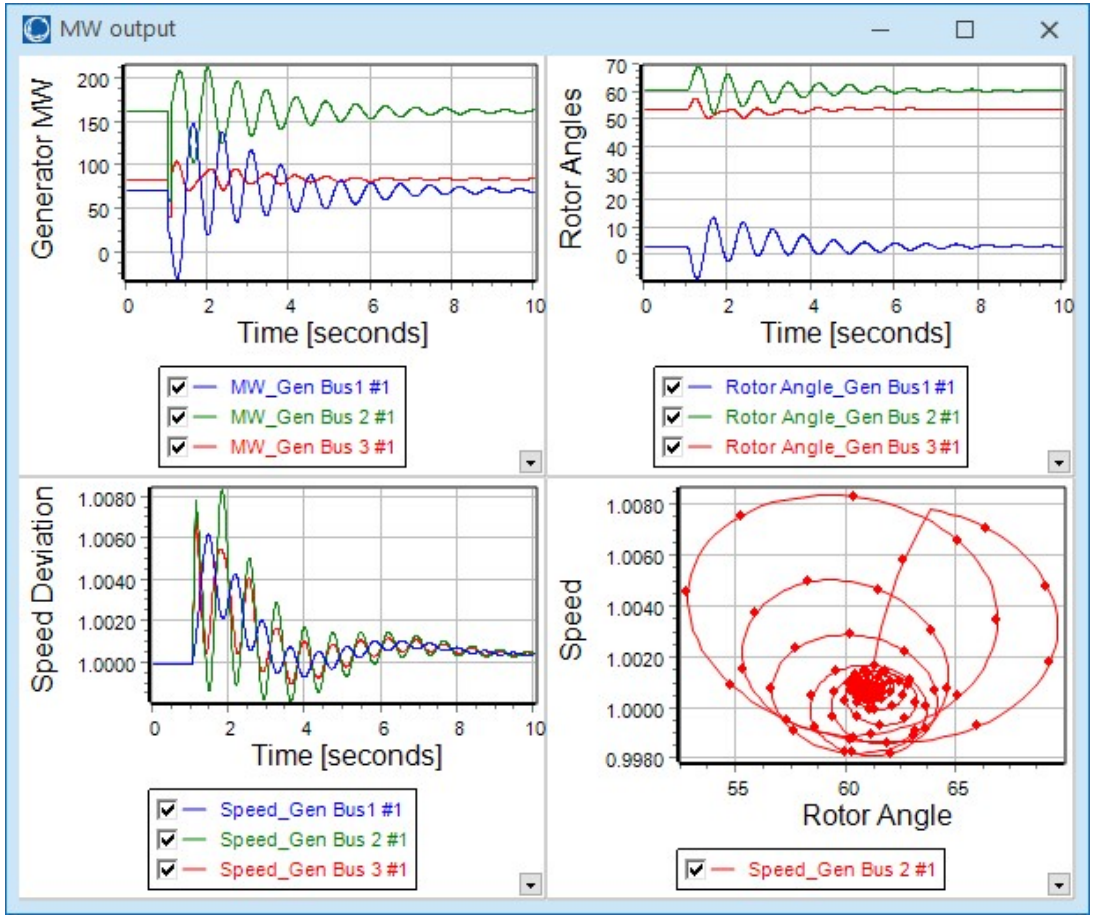
Confirm the decision to delete the record

Table showing the new Transient Contingency Elements



Example: Changing Contingency Elements

- The new events may also be loaded from TS9ChangeCtg.aux
- You have now changed what events will be simulated for this Transient Contingency
- Click “Run Transient Stability” to re-run the simulation to simulate a branch fault between Buses 4 and 5 fault located near Bus 5
- The plots should look the same as when you simulated this as a bus fault



Multiple Contingencies

- In most of the training, we just talk about simulating a single transient contingency event
- Simulator facilitates the definition of multiple transient contingency scenarios within the same case
- These Multiple Transient Contingencies may be defined and simulated, either individually or all together
- Changing the Process Contingencies option from “One Contingency at a time” to “Multiple Contingencies” will change the dialog in small ways throughout
- This will be discussed later

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